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# Facility Defense Against Aerosol Attack

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**3 April 2002**

50  
years



MS-15434

This work was sponsored under Air Force contract F19628-00-C-0002. The views expressed are those of the Author and do not reflect official policy or position of the United States Government.

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**MIT Lincoln Laboratory**

## Report Documentation Page

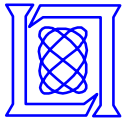
<b>Report Date</b> 03APR2002	<b>Report Type</b> N/A	<b>Dates Covered (from... to)</b> 03APR2002 - 04APR2002
<b>Title and Subtitle</b> Facility Defense Against Aerosol Attack	<b>Contract Number</b> F19628-00-C-0002	
	<b>Grant Number</b>	
	<b>Program Element Number</b>	
<b>Author(s)</b> Cousins, Dan	<b>Project Number</b>	
	<b>Task Number</b>	
	<b>Work Unit Number</b>	
<b>Performing Organization Name(s) and Address(es)</b> MIT Lincoln Laboratory	<b>Performing Organization Report Number</b>	
<b>Sponsoring/Monitoring Agency Name(s) and Address(es)</b> Air Force ESC/XPB (Richard Axtell) Hanscom AFB, MA 01731	<b>Sponsor/Monitor's Acronym(s)</b>	
	<b>Sponsor/Monitor's Report Number(s)</b>	
<b>Distribution/Availability Statement</b> Approved for public release, distribution unlimited		
<b>Supplementary Notes</b> Workshop paper from the New England Bioterrorism Preparedness Workshop held 3-4 april 2002 at MIT Lincoln Laboratory, Lexington, MA, The original document contains color images.		
<b>Abstract</b>		
<b>Subject Terms</b>		
<b>Report Classification</b> unclassified	<b>Classification of this page</b> unclassified	
<b>Classification of Abstract</b> unclassified	<b>Limitation of Abstract</b> SAR	
<b>Number of Pages</b> 19		



# Outline

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- **Facilities and attack scenarios**
- **Sensing an attack**
- **Facility protection techniques**



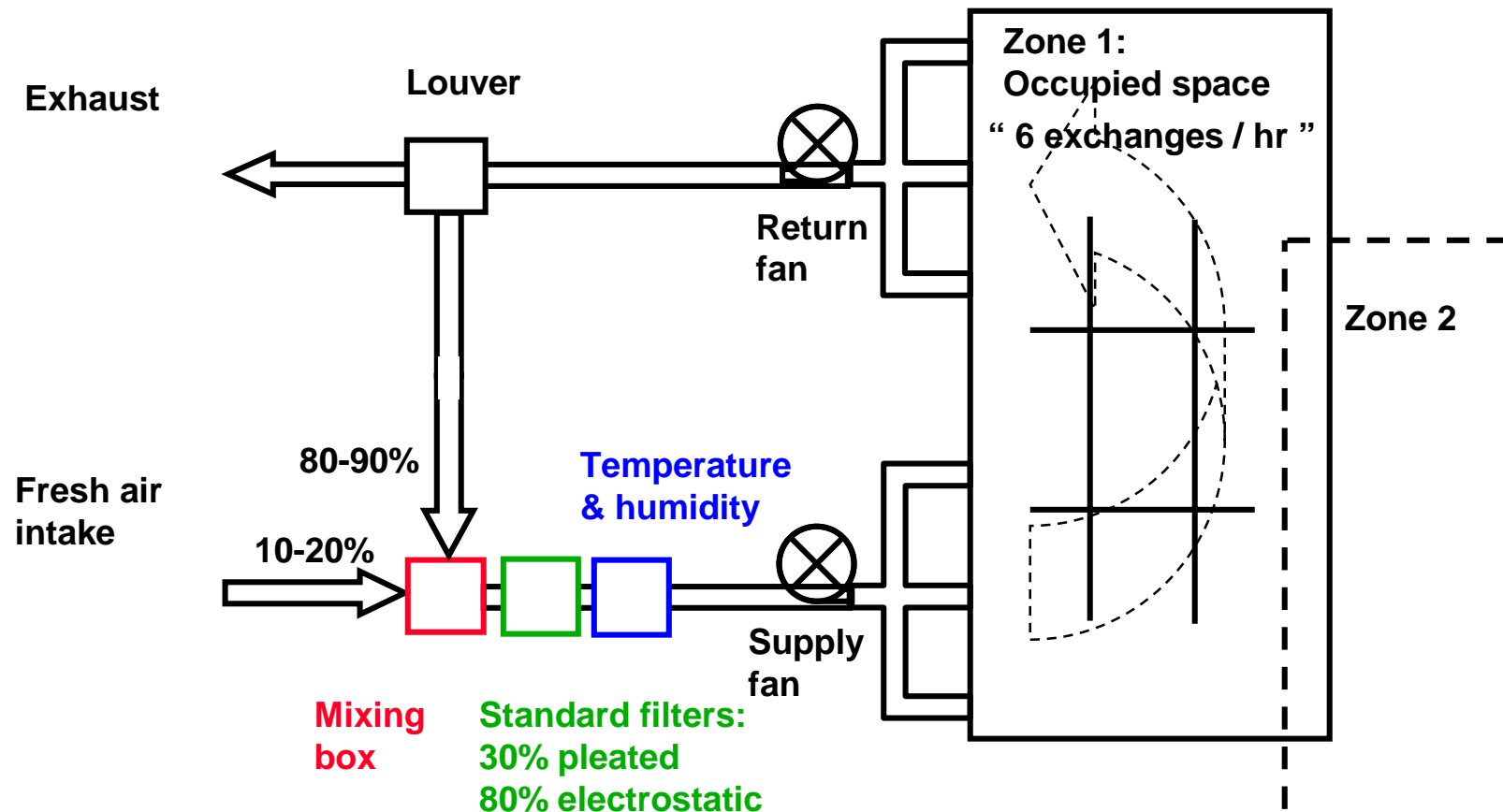
# Types of facilities

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- **Simple structures**
  - Residences, barracks
- **Buildings with ventilation system**
  - **Multiroom office building**
  - Large open space (arena, terminal, ...)
- **Subway**
- **Outdoor sites**
  - Stadium
  - Public gathering
  - Military operations



# Simplified Ventilating System





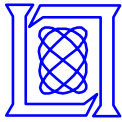
# Types of Attacks

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- **External attacks**
  - Nearby cloud release
  - Burst release into air intake
- **Internal attacks**
  - Burst release into air return
  - Burst release into a large open space
  - Low level continuous release
- **Small amounts of agent are substantial threats**

1 gram bioagent uniformly dispersed into  $10^8$  liter building (100m x 100m x 10m);

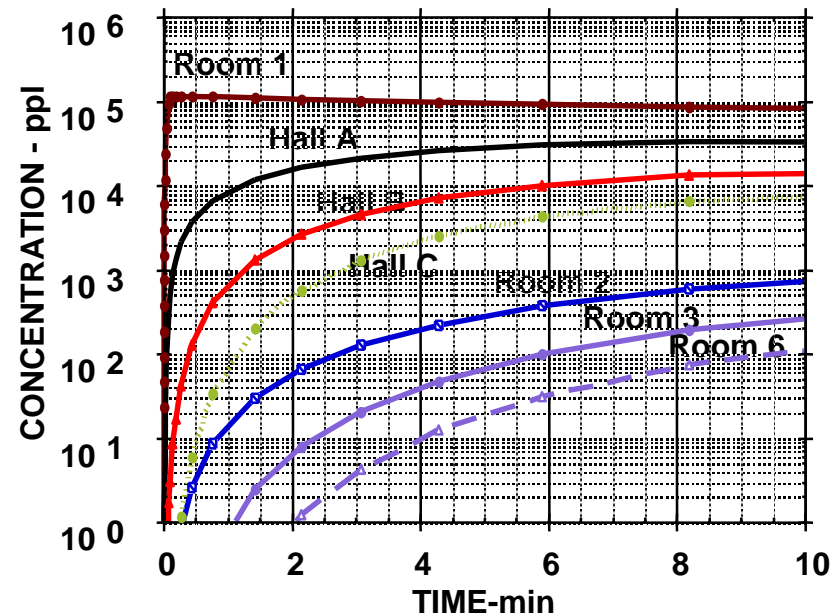
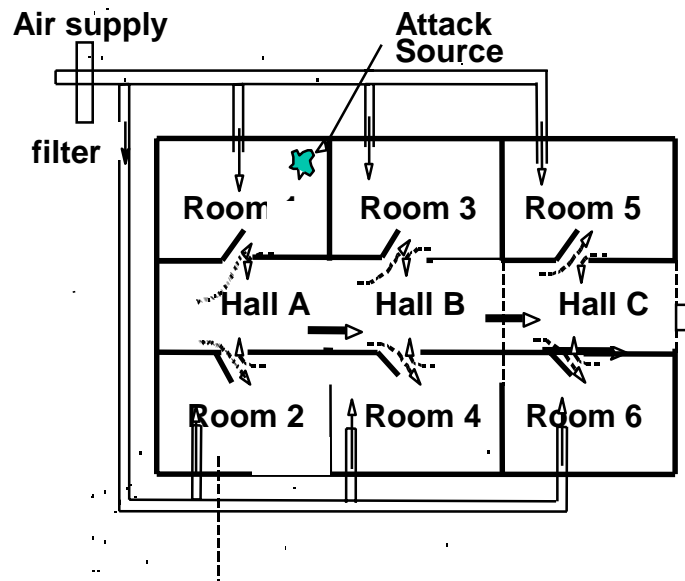
Corresponds to lethal exposure (100 ppl x 10 liter/min x 10 min;  $10^{10}$  particles /gram)



# Modeling an Attack

## Burst release in an interior room

- Bioagent - 15 grams over 5 sec
- Room-Hall coupling - 10%



- Lumped parameter models are well established  
instantaneous and uniform concentration within each room
- Initial particle dispersal and deposition are more complicated to model.

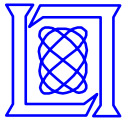


# Emergency Management Measures

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- **Information**
  - **Observing suspicious activity**
  - **Knowing who to treat**
    - › **Primarily, but not exclusively, bio agents**
    - › **Records of access (badge swipes, tickets,...)**
    - › **Voluntary response to public announcement**
    - › **Physical examination**
  - **Preserving forensic evidence**
- **Plan of action**
  - **HVAC emergency management decision tree**
    - › **Suspicious event near air intake -> shut down intake**
    - › **Suspicious event inside building -> full fresh air**
  - **Communication channels**
  - **Evacuation plan**
    - › **Orderly movement to controlled safe area, avoid cross contamination**





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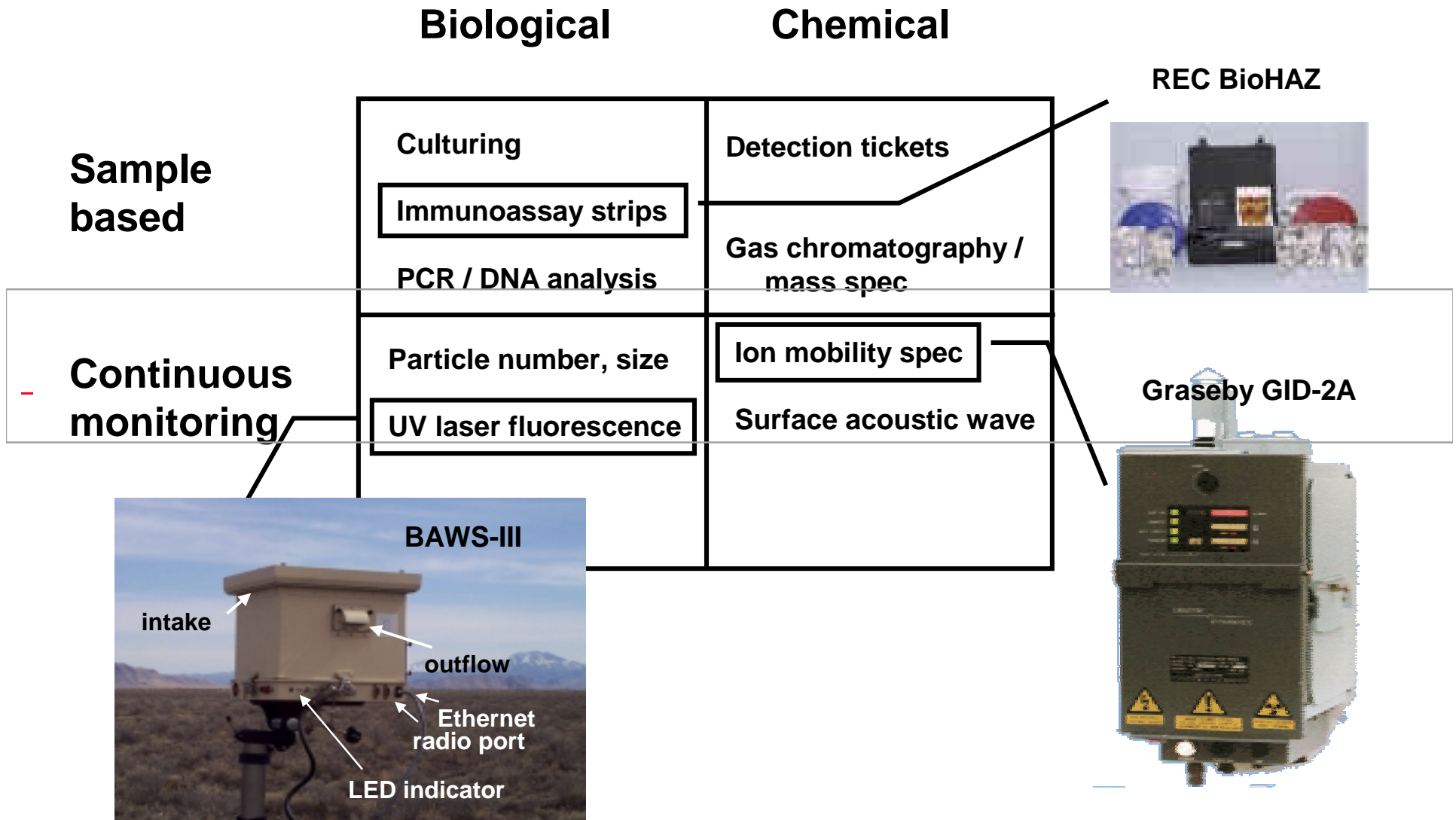
# Rationale for Sensing

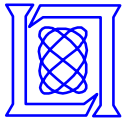
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- **Issue alarm**
  - initiate facility response
  - high  $\text{Prob}_{\text{detection}}$  ; low  $\text{Prob}_{\text{false alarm}}$  ; wide range of agents
- **Identification of agent**
  - initiate medical treatment
- **Mapping of contamination zone**
- **Assessing decontamination (“all-clear”)**

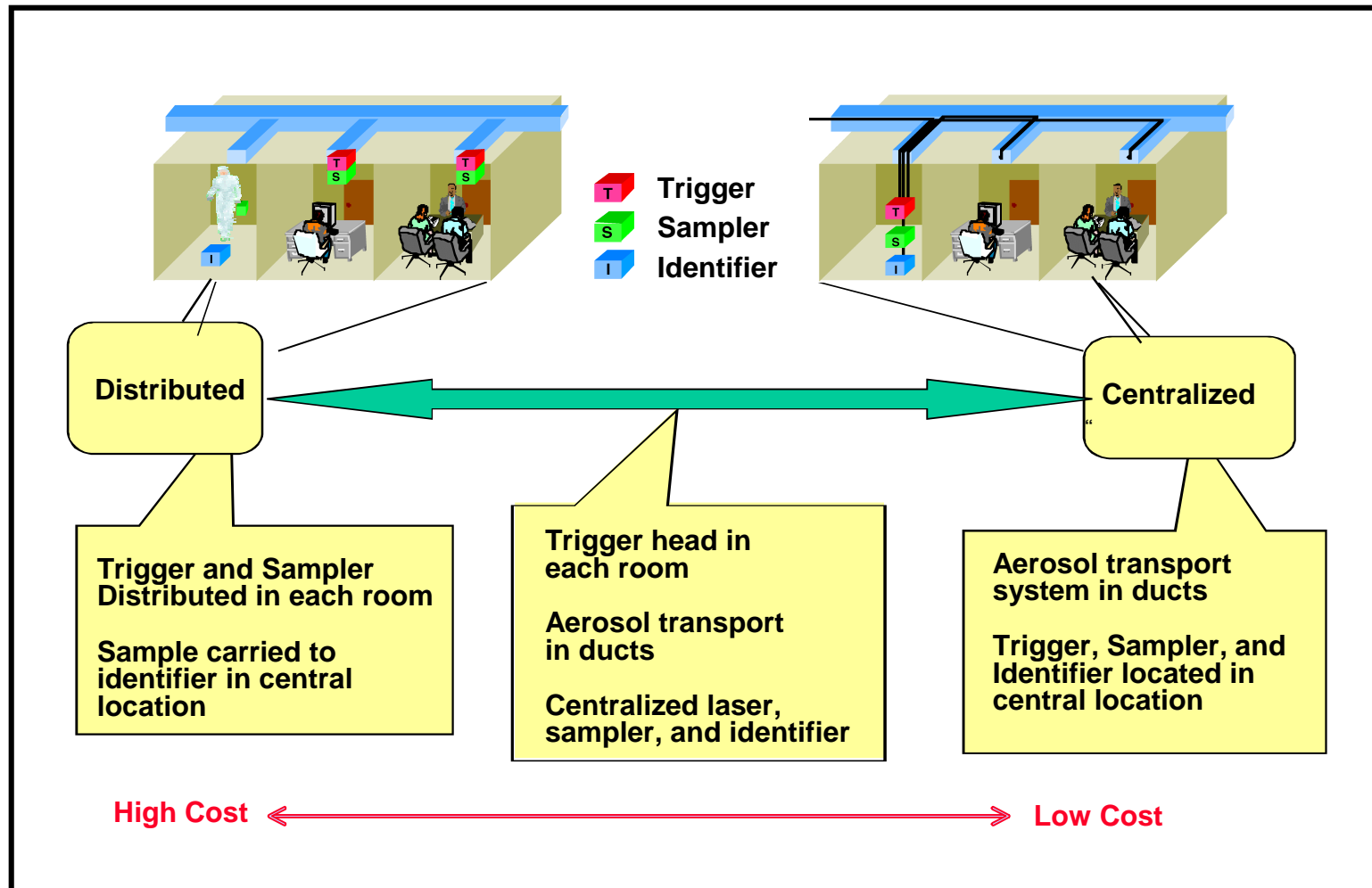


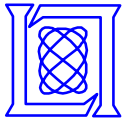
# State-of-the-Art Bio / Chem Sensors



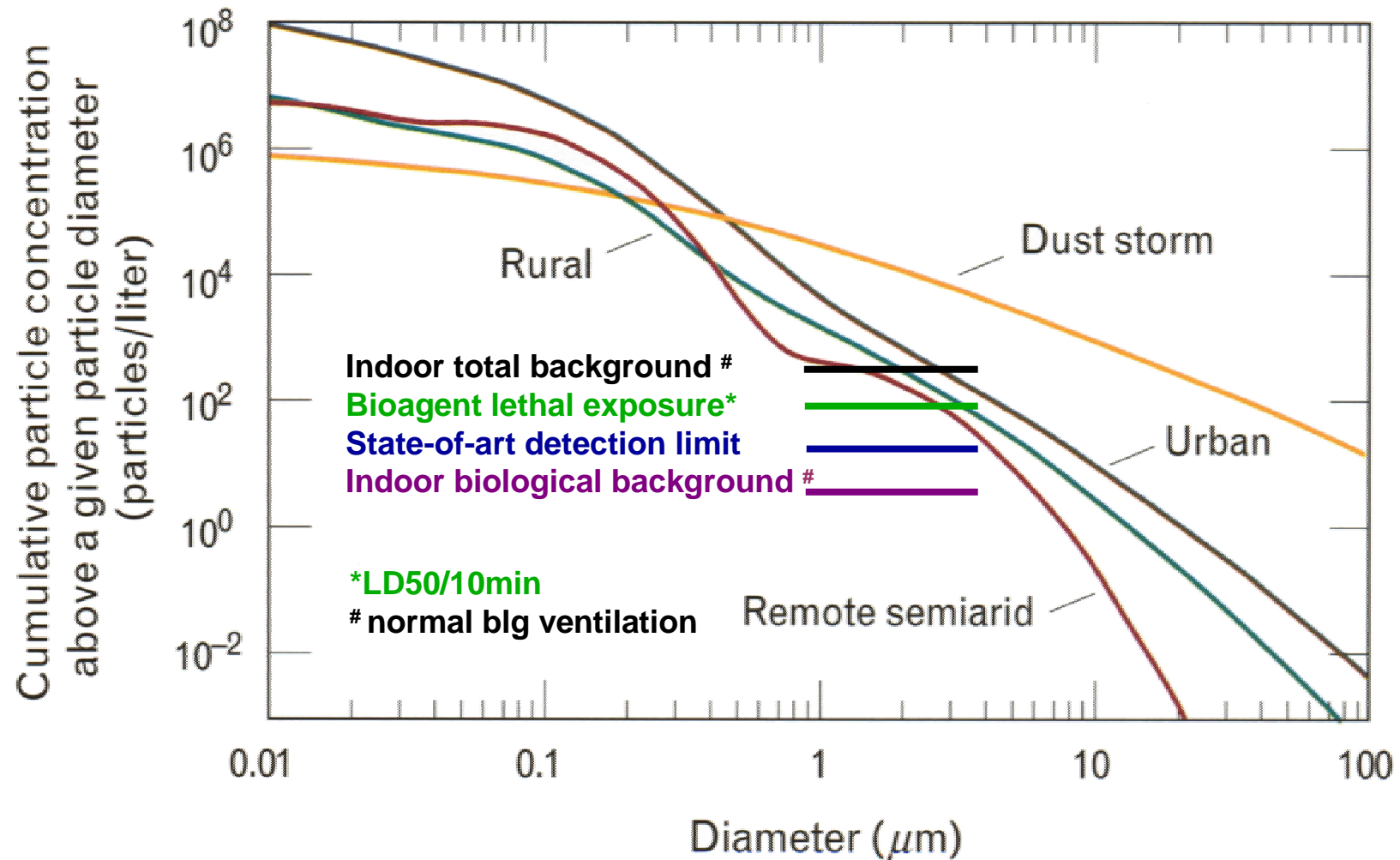


# Sensor Architectures for Building Defense





# Atmospheric Aerosol Content

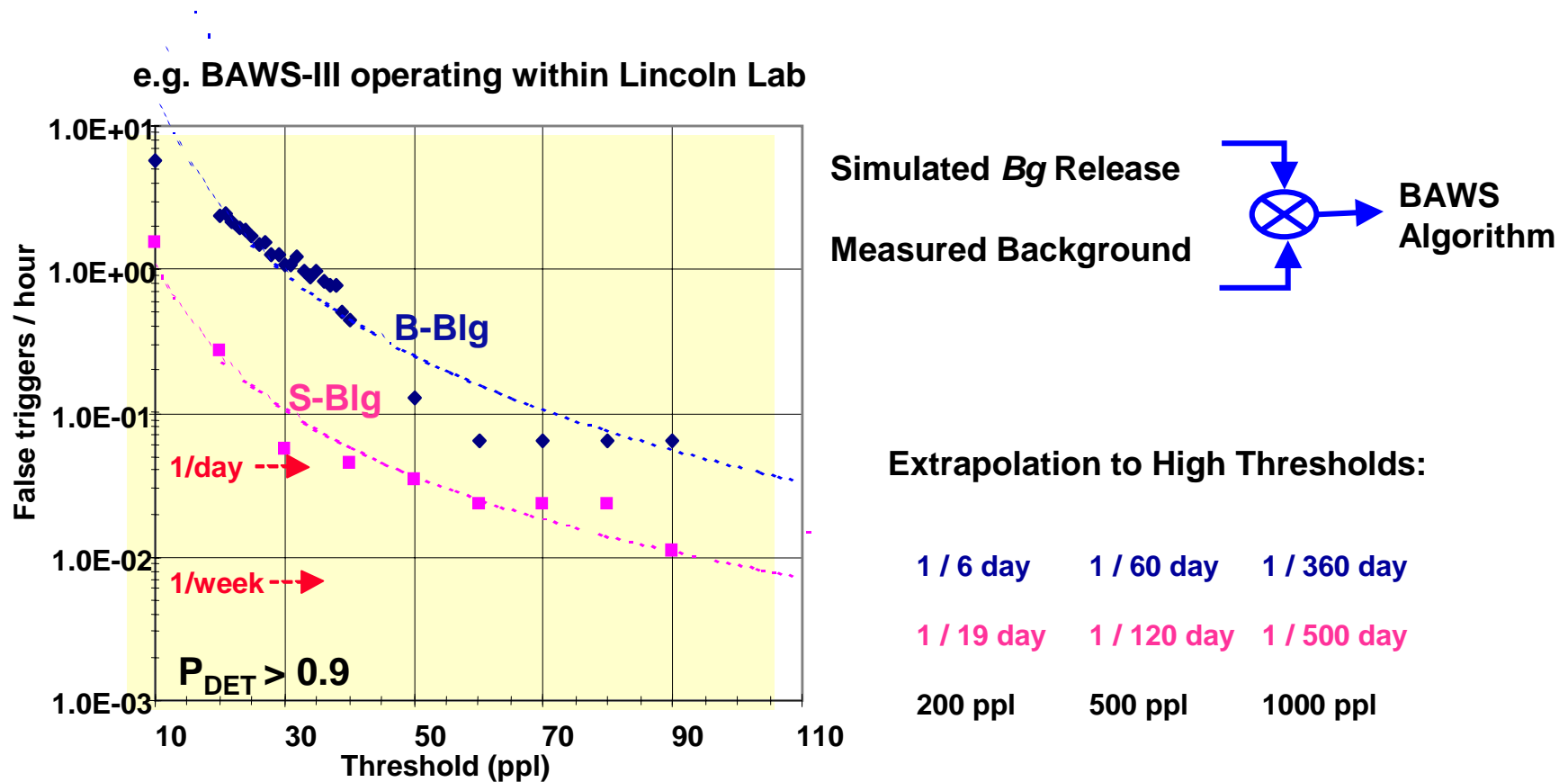


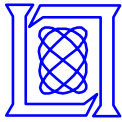
After R. Jaenicke in *Aerosol-Cloud-Climate Interactions*, P. Hobbs editor (1993).



# False Trigger Rate

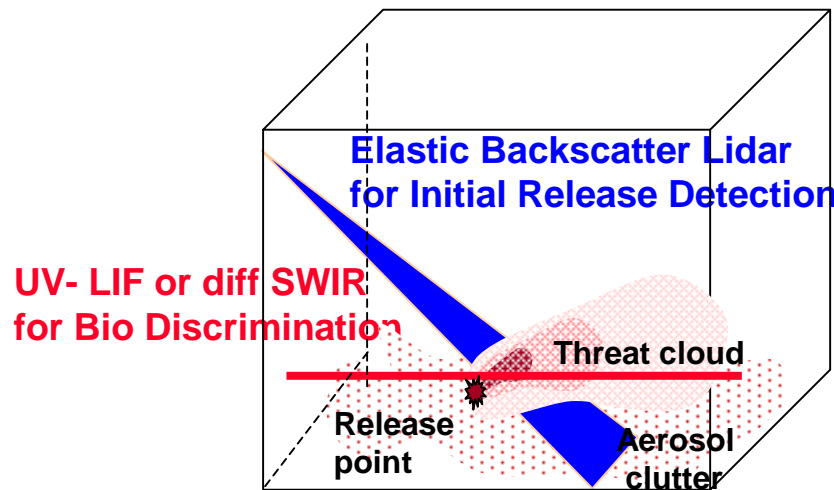
- Sensor will trigger less frequently when operated at higher threshold.





# Indoor Standoff Aerosol Detection

- Any point sensor is limited by aerosol transport in large open space.
- Need to detect the release promptly at a specific point
- Bio sensor concept:



Minimum for detecting 1000ppl threat

	Dwell time	Range cell
Elastic	0.1 sec	1 m
UV LIF	10 sec	3 m
Diff SWIR	10 sec	2 m

50m range, eyesafe laser; 100 lux lighting

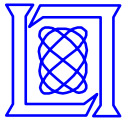


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# Facility Protection Measures

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- **Physical security**
  - **Protect fresh air intakes (location, access, surveillance)**
  - **Personal screening (may be difficult in civil defense)**
- **Ventilation system protection**
  - **Passive air filtration**
    - › **Upgrade filters (best ASHRAE filters > 95%)**
    - › **Overhauling the system (HEPA / carbon)**
  - **Positive pressure to overcome infiltration**
  - **Sensor triggered airflow control**



# Passive Air Filtration

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- **In-line passive filtration is well established**
  - HEPA filters remove >99.97% suspended particles > 0.3  $\mu\text{m}$ .
  - Activated carbon filters adsorb most chemical vapors
- **Substantial cost to overhaul existing ventilation system**
  - Purchase and replacement of filters
  - Increased blower motors for higher pressure drop
  - Reinforced ductwork
  - Very little infiltration is allowable (gasket seals, overpressure)
  - Increased energy costs
- **Research topics**
  - Low pressure drop filter structures
  - In-line sterilization (UV, radiation, thermal,...)

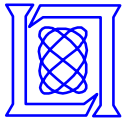


# Facility Defense Effectiveness

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Estimated exposure reduction  
to external bio attack

- |  |          |
|--|----------|
| • “Unprotected” building   | 1        |
| • Upgraded standard filters<br>(or in-room HEPA)                             | 10-100   |
| • In-line HEPA filters   | 100-1000 |
| • In-line HEPA filters<br>with overpressure<br>and triggered airflow control | > 1000   |



# Summary

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- **Most buildings with ventilation systems are vulnerable to aerosol attack via a number of scenarios.**
- **Without deployed sensors, an attack may go undetected resulting in higher exposure and lack of treatment to exposed occupants.**
- **There are some simple measures that can be used to increase situational awareness and provide limited protection.**
- **A substantial degree of protection can be achieved at substantial cost with sensor triggered airflow control and HEPA/carbon filters. In this case, sensors may be operated at higher thresholds.**